

REMARKS

Claims 1-4, drawn to the elected species, and claims 5-8, directed to non-elected species, are pending; the non-elected claims stand withdrawn. Both elected and non-elected claims have been amended. Minor self-evident changes have been made in the specification also.

1. The election of species requirement was traversed in the Confirmation of Telephone Election filed December 12, 2002. As discussed below, claim 1 as amended is patentable over the art of record; thus, applicants request that (1) the election of species requirement be reconsidered and withdrawn and (2) the additional species of claims 5-8 also be examined and allowed. See MPEP 809.02(c) part (B), discussed below.

2. Claims 1-4 were rejected under 35 U.S.C. 112, second paragraph, as indefinite. Claims 1-3 are amended to more particularly point out and distinctly claim the invention; applicants respectfully submit that the claims as amended comply with the formal requirements of the Patent Code.

Claims 1-3 have been amended to indent the various steps of the method as requested by the Examiner.

The phrase "the predetermined cells" in claim 2, line 7, has been amended to read "said cells to be plugged with said plugging material" to provide antecedent support for the recited cells.

When considering the invention, one needs to bear in mind the difference between the terms "plugging material" and "plugging slurry." The ultimate goal of the instant method is to make a diesel filter from a ceramic honeycomb having a pattern of honeycomb cells closed with a ceramic material at the first end. Then, the remaining open cells are closed with ceramic material at the opposite, second end.

The ceramic material that is inserted into these cell ends for cell closure is the ceramic "plugging slurry." The ceramic honeycomb has each end sequentially immersed into the ceramic plugging slurry. To prevent this ceramic plugging slurry from flowing into cell ends that are ultimately intended to remain open, one must temporarily plug these intended-to-be "open" cell ends with a "plugging material" which, in the preferred embodiment, is in the form of paraffin balls (i.e. paraffin wax). The plugging material prevents the ceramic plugging slurry from flowing into the intended-to-be open end cells when the end of the honeycomb is immersed in the plugging slurry.

In the final production step, after either one or both ends of the honeycomb is/are immersed in the ceramic slurry, the honeycomb is dried and then fired to sinter the plugging slurry to seal the various cell ends. It is at this time of drying or sintering that the temporary "plugging material" is removed.

According, review and withdrawal of the rejection is requested.

3. Claim 1 was rejected under 35 U.S.C. 102(b) as anticipated by Oyobe et al. (4,519,820). Claim 1 is amended to more particularly point out and distinctly claim the invention and applicants traverse any rejection of amended claim 1 on this basis.

Oyobe et al. '820 shows in Fig. 17(a) a method of producing a ceramic body with alternately plugged cells by first uniformly filling all of the cells at each end with a plugging material (e.g., wax 20). See col. 6, lines 62-64.

FIG.17(a)

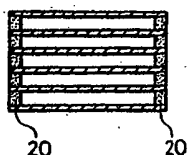
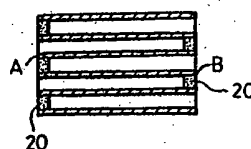


FIG.17(b)



Then, as shown in FIG. 17(b), some of the wax plugs 20 are removed, i.e., the wax plugs 20 at one end A of each passage are removed from every other passage, whereas, at the other end B, the wax plugs 20 are removed from those passages where the opposite ends A are still plugged.

The reference process is a completely different plugging process from applicants' process. Oyobe et al. '820 first fill all of the cells with the wax plugs and then afterwards selectively remove the unwanted cell plugs in a desired pattern. This process is very labor intensive as it requires small cells (i.e. the honeycomb structures can have hundreds of cells per square inch) to be selectively and individually treated to remove the plugs from the cells.

In applicants' process the plugging material is applied only to the specific desired cells where applicants want to have the wax present. The filling step in claim 1 as amended reads:

filling a plugging material [for] that forms a mask into the only cells to be opened at one end face of the ceramic honeycomb formed body where the plugging material is filled.

This claim language tells the reader that where one wants to have an open cell in the final honeycomb product, then at this early filling step the plugging material is to be applied only

to those intended-to-be-open cell ends. Such a process of selectively applying the plugging material (e.g. wax) to form the intended protective mask pattern is not taught by or suggested Oyobe et al. '820 which discuss initially applying wax to all of the cells. Accordingly, claim 1 as amended patentably distinguishes over the Oyobe et al. '820. Review and withdrawal of this rejection as applied to claim 1 is requested.

Applicants thank the Examiner for indicating that claims 2-4 directed to the elected specie of using a suction jig selectively to apply the plugging material are patentable.

Because generic claim 1 is patentable over Oyobe et al. '820 for the reasons above, applicants request that the two additional species of claims 5-8 be examined and allowed at this time.

Claims 5 and 6 are directed to the specie where the plugging material for the mask filling step is applied by providing a sheet over the end of the honeycomb with holes in it so the plugging material flows through the holes under pressure. This embodiment is illustrated in Figs. 8-11.

Claims 7 and 8 are directed to the species where the plugging material for the mask filling step is applied by immersing one end face of the honeycomb in a photo-curing

resin and applying a light through a mask to harden the resin in the desired cells.

MPEP 809.02(c) part (B) provides that when a generic claim is subsequently found allowable the Examiner is to indicate that the claims drawn to the non-elected species are no longer withdrawn because they are fully embraced by the allowed generic claim. This procedure applies when there are not more than a reasonable number of species claimed; here there are only two additional species.

Applicants respectfully submit that the present application is now in condition for allowance. Accordingly, the Examiner is requested to issue a Notice of Allowance for all pending claims including the non-elected claims 5-8.

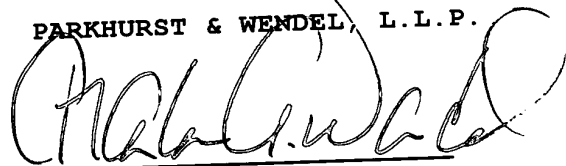
Serial No.: 10/030,434

Atty. Docket No.: NSUG:849

Should the Examiner deem that any further action by the applicants would be desirable for placing this application in even better condition for issue, the Examiner is requested to telephone applicants' undersigned representative at the number listed below.

Respectfully submitted,

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February 6, 2003  
Date

Attachment: Version with Markings  
to Show Changes Made

CAW:EC/ame

Attorney Docket No.: NSUG:849

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## Specification

## METHOD OF PRODUCING CERAMIC BODY

Technical Field

The present invention relates to a method of producing a ceramic body having a construction such that cells are plugged alternately at both end faces of a ceramic honeycomb structural body.

Background Art

Up to now, in order to produce a ceramic body in which cells are plugged alternately at both end faces of a ceramic honeycomb structural body, various producing methods have been known. Figs. 15a-15c are schematic views respectively explaining one embodiment of a method of producing such a known ceramic body. According to Figs. 15a-15c, one embodiment of the known method of producing the ceramic body will be explained. At first, as shown in Fig. 15a, a mask 54 made of rubber having holes 53 corresponding to cells 52 to be plugged at an end face of a ceramic honeycomb formed body 51 (ceramic honeycomb structural body before sintering) is prepared, and the thus prepared mask 54 is set at a predetermined position on the end face of the ceramic honeycomb formed body 51 by hand.

Then, as shown in Fig. 15b, the end face of the ceramic honeycomb formed body 51, to which the mask 54 is set, is immersed in a plugging slurry 55, and, a pressure is applied to the ceramic honeycomb formed body 51 from above, so that the cells 52 are filled with the slurry 55 through the holes 53 of the mask 54. At the other end face of the ceramic honeycomb formed body 51, predetermined cells 52 are filled with the slurry 55 in the same manner. In this case, a mask having a reverse hole pattern such that holes are arranged at portions where no holes 53 of the mask 54 are arranged is used so as to obtain a construction such that the cells 52 are plugged alternately at both end faces of the ceramic honeycomb structural body. According to the processes



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mentioned above, as shown in Fig. 15c by cross section, it is possible to obtain the ceramic honeycomb formed body 51 having a construction such that the cells 2 are plugged alternately at its both end faces. Finally, the thus obtained ceramic honeycomb body 51 is sintered so as to obtain a ceramic body according to the invention.

However, in the method of producing the known ceramic body mentioned above, it is difficult to make the mask 54 having the predetermined holes 53 and to set the mask 54 accurately on the end face of the ceramic honeycomb formed body 51. Particularly, in a large size ceramic body having a diameter of about 300 mm which is recently required, the number of cells 52 at the end face reaches to few ten-thousands, and thus the difficulties mentioned above become worse. Moreover, since the mask 54 is set on the end face of the ceramic honeycomb formed body 51 by hand, it is necessary for a worker to get skillful and this setting operation requires much time. In addition, there is a problem such that this setting operation is not automated. Further, after the plugging operation, it is necessary to perform a cleaning operation of the mask 54 for recycling. However, since the mask 54 has a large number of cells as mentioned above, there is a problem such that it is very difficult to clean up the mask 54.

**Disclosure of Invention**

An object of the invention is to eliminate the drawbacks mentioned above and to provide a method of producing a ceramic body which can easily plug cells at an end face and which can be easily automated.

According to a method of producing a ceramic body according to the invention, a method of producing a ceramic body having a construction such that cells are plugged alternately at both end faces of a ceramic honeycomb structural body by filling a plugging slurry into predetermined cells at both end faces of a ceramic honeycomb formed body, comprises the steps of: filling a plugging material for mask into

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as shown in Fig. 3b, the paraffin balls 3 are filled into the cells 2 to be opened at the both end faces of the ceramic honeycomb formed body 1 as a plugging material for mask.

Then, as shown in Fig. 4a, the end face of the thus obtained ceramic honeycomb formed body 1 is immersed into a plugging slurry 7 stored in a vessel 6. Then, as shown in Fig. 4b, the plugging slurry 7 is filled into the predetermined cells 2, to which the paraffin balls 3 are not filled, by applying a pressure to the ceramic honeycomb formed body 1 from upward by means of a pressurized means 8. The same operations are performed repeatedly with respect to the other end face. As a result, as shown in Fig. 4c, it is possible to obtain the ceramic honeycomb formed body 1 in which the plugging slurry 7 is filled into the cells 2 at the both end faces to which the paraffin balls 2 are not filled.

Then, the thus obtained ceramic honeycomb formed body 1 is sintered as is the same manner as that of the known manner after drying. At the drying step or the sintering step, the plugging slurry 7 is dried and sintered so as to integrate with a cell wall 9. At the same time, the paraffin balls 3 are melted and removed. As a result, as shown in Fig. 5, it is possible to obtain a ceramic body 10 having a construction such that the cells 2 are plugged alternately at the both end faces of the ceramic honeycomb structural body.

As mentioned above, the method of filling the paraffin balls are finished. Hereinafter, as a preferable method of aligning the paraffin balls 3 to the predetermined cells 2, (a) method of utilizing a setter (formed body having the same honeycomb structure as that of the ceramic honeycomb formed body) as a paraffin ball suction jig, and (b) method of utilizing the ceramic honeycomb formed body itself as the paraffin ball suction jig will be explained.

(a) As to a method of utilizing the setter as the paraffin ball suction jig (Figs. 6a and 6b):

In this method, a setter 21 is formed simultaneously when the ceramic honeycomb formed body 1 is formed and is utilized as the

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suction jig. A mask 23 having a construction such that holes 22 are arranged in a checkered pattern at positions corresponding to the cells to be plugged is adhered to an upper face of the setter 21. The mask 23 may be formed by rubber, resin, paper and so on. The setter 21 is set to the vacuum apparatus 4 in such a manner that the surface, to which the mask 23 is adhered, is positioned upward. Then, the setter 21 approaches to the tray 5 in which the paraffin balls 3 are stored, and the suction apparatus 4 starts to work. As a result, the paraffin balls 3 are sucked in a checkered pattern on an under face of the setter 21. Then, the setter 21 is set on the end face of the ceramic honeycomb formed body 1 positioned by for example an image processing apparatus, and the vacuum apparatus 4 is stopped. In this manner, the paraffin balls 3 are aligned to the end face of the ceramic honeycomb formed body 1. Then, the same aligning operations are performed for the other end face by utilizing the setter 21, to which another mask 23 is adhered, so that the paraffin balls 3 can be aligned at the both end faces.

(b) As to a method of utilizing the ceramic honeycomb formed body itself as the paraffin ball suction jig (Figs. 7a-7d):

In this method, the ceramic honeycomb formed body 1, in which the paraffin balls 23 are filled to the cells 2 at one end face, is utilized as the suction jig for filling the paraffin balls 3 to a next ceramic honeycomb formed body 1. At first, as shown in Fig. 7a, a ceramic honeycomb formed body 1-1, to which the mask 23 is adhered, is utilized for the first ceramic honeycomb formed body 1. Then, the paraffin balls 3 are aligned to the predetermined cells 2 at the end face of a next ceramic honeycomb formed body 1-2 in the same manner as that of the embodiment mentioned above except that the ceramic honeycomb formed body 1-1 is utilized as the setter 21 (Fig. 7b). After that, the paraffin balls 3 are aligned to the predetermined cells 2 at the end face of a further next ceramic honeycomb formed body 1-3 (Fig. 7d) in the same manner as that of the embodiment mentioned above except that the ceramic honeycomb formed body 1-2, in which the paraffin balls 3 are

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aligned at one end face, is utilized as the setter 21 (Fig. 7c). The above operations are repeated, so that the paraffin balls 3 are aligned at the both end faces.

(2) As to a method of filling liquid paraffin through holes arranged to a sheet:

Firstly, as shown in Fig. 8, an image of the end face of the ceramic honeycomb formed body 1 is picked-up by a camera 31, and the thus picked-up image is subjected to an image processing. In this manner, positions of all the cells 2 at the end face are recognized.

Then, as shown in Fig. 9a, a sheet 32 having a dimension substantially equal to the end face of the ceramic honeycomb formed body 1 is prepared. Then, as shown in Fig. 9b, the thus prepared sheet 32 is adhered to the overall end face, the cell positions of which are recognized. As the sheet 32, a commercially available adhesive sheet can be used.

Then, as shown in Figs. 10a and 10b, reference positions of small blocks defined according to a specification of the ceramic honeycomb formed body 1 such as outer diameter and cell pitch are calculated on the basis of the cell positions which are recognized by an image processing, and holes 33 are opened at the cell positions to be opened of the sheet 32 by means of a laser machining and so on, while the ceramic honeycomb formed body 1 is positioned by means of an XYZ $\theta$  stage. The sheet 32 having the holes 33 functions as the mask. The hole 33 has a circular shape, and it is not necessary to open to an extent such that the hole 33 has the same (quadrangle) shape as that of the cell 2. Therefore, even in the case that a slight cell pitch variation occurs at the end face, there is no risk for piercing a cell wall and further a next cell, since a diameter of the hole 33 is smaller than the cell 2. In this case, it is preferred to set a diameter of the hole 33 corresponding to a viscosity of a melted liquid-like paraffin in such a manner that it is smaller when the viscosity is low and it is larger then the viscosity is high. Moreover, it is preferred to perform the above hole machining with respect to the sheet 32 for respective small blocks that are formed by dividing the cells 2 at

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use the known photo-curing resin as the photo-curing resin 41.

Then, as shown in Fig. 13a, a mask 44 utilizing a liquid crystal is set to the end face of the ceramic honeycomb formed body 1 to which the cell positions are recognized, and the mask 44 is varied in a checkered pattern in such a manner that a light is introduced only to the cells to be opened on the basis of the position data of all the cells 2 obtained by an image processing. Then, as shown in Fig. 13b, a light emanating from a light source 45 is introduced to the end face of the ceramic honeycomb formed body 1 through the mask 44. By introducing a light through the cells 2, the photo-curing resin existing at the cells 2, through which a light is transmitted, is hardened. Moreover, as shown in Fig. 13c, the end face of the ceramic honeycomb formed body 1 is plugged by the hardened resin.

As to the other end face, the plugged resin 41 functions as the mask, since a light is shielded by the plugged resin. Therefore, as shown in Fig. 14a, the other end face is immersed into the photo-curing resin 41 stored in the tray 42, and a light emanating from the light source 45 is introduced to the end face of the ceramic honeycomb formed body 1. In this manner, as shown in Fig. 14b, the photo-curing resin 41 existing in the desired cells 2 is hardened. In this case, in order to plug all the outer peripheral portion of the ceramic honeycomb formed body 1, a light is not introduced to the photo-curing resin 41 at a peripheral portion by using a fixed mask 46 as shown in Fig. 14a.

Then, as explained by the previous embodiment shown in Figs. 4a-4c, the plugging slurry 7 is filled into the cells 2 that are not plugged by the photo-curing resin 41 (corresponding to the paraffin 3 in Fig. 4) according to the known method. After that, the thus obtained ceramic honeycomb formed body 1 is dried and sintered, so that the photo-curing resin 41 is removed and the plugging slurry 7 is integrated with the cell wall. Accordingly, it is possible to obtain the ceramic body 10 as shown in Fig. 5.

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## Claims

1. (Amended) A method of producing a ceramic body having a construction such that cells are plugged alternately at both end faces of a ceramic honeycomb structural body by filling a plugging slurry into predetermined cells at both end faces of a ceramic honeycomb formed body, the method comprising the steps of:

filling a plugging material ~~for~~that forms a mask into only the cells to be opened at one end face of the ceramic honeycomb formed body where the plugging material is filled;

immersing the end face, to which the plugging material ~~for~~that forms a mask is filled, into a plugging slurry; and

drying and sintering the ceramic honeycomb formed body while the plugging material ~~for~~that forms a mask is removed during a drying step or a sintering step.

2. (Amended) The method of producing a ceramic body according to claim 1, wherein the plugging material ~~for~~that forms a mask filling step further ~~comprising~~comprises the steps of:

preparing a suction jig having a same honeycomb construction as that of the ceramic honeycomb formed body;

adhering a mask, in which holes are arranged corresponding to the cells to be plugged with said plugging material, to one end face of the suction jig;

sucking paraffin balls, a diameter of which is larger than a length of one side of the cell, to the ~~predetermined~~said cells to be plugged with said plugging material at the other end face by sucking from the end face to which the mask is adhered;

setting the suction jig, to which paraffin balls are sucked, to the end face of the ceramic honeycomb formed body to which the plugging material is to be filled;

aligning the paraffin balls to the cells to be opened by stopping the sucking operation;

inserting the thus aligned paraffin balls into the cells by applying

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pressure; and

\_\_\_\_\_ filling the paraffin balls into the cells to be opened as the plugging material ~~for~~that forms a mask.

3. (Amended) The method of producing a ceramic body according to claim 2, ~~wherein the improvement~~ further comprising the steps of:

\_\_\_\_\_ sucking the paraffin balls to the other end face by sucking from the one end face to which the paraffin balls are filled;

\_\_\_\_\_ inserting the thus sucked paraffin balls into the cells by applying a pressure; and

\_\_\_\_\_ filling the paraffin balls into the cells to be opened of the other end face.

4. The method of producing a ceramic body according to claim 2, wherein the ceramic honeycomb formed body, in which the paraffin balls are filled into the cells of the one end face, is used as the suction jig for filling the paraffin balls of the next ceramic honeycomb formed body.

5. (Amended) The method of producing a ceramic body according to claim 1, wherein the plugging material ~~for~~that forms a mask filling step further ~~comprising~~comprises the steps of:

\_\_\_\_\_ making a mask for respective ceramic honeycomb formed bodies by piercing a sheet adhered to one end face of the ceramic honeycomb formed body at positions corresponding to the cells to be plugged;

\_\_\_\_\_ immersing the one end face to which the mask is adhered into a liquid paraffin;

\_\_\_\_\_ inserting the liquid paraffin into the cells through the holes of the mask by applying a pressure; and

\_\_\_\_\_ filling the liquid paraffin into the cells to be opened as the plugging material ~~for~~that forms a mask.

6. (Amended) The method of producing a ceramic body according to claim 5, wherein the piercing step to the sheet adhered to one end face of the ceramic honeycomb formed body further ~~comprising~~comprises a step of:

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\_\_\_\_ dividing the cells of the end face into a plurality of small blocks;  
and

\_\_\_\_ performing the piercing for respective small blocks one by one.

7. (Amended) The method of producing a ceramic body according to claim 1, wherein the plugging material ~~for~~that forms a mask filling step further ~~comprising~~comprises the steps of:

\_\_\_\_ immersing one end face of the ceramic honeycomb formed body into a photo-curing resin before hardening;

\_\_\_\_ emanating a light to the photo-curing resin from the other end face through a mask, in which a light is transmitted only to the cells to be opened, so as to harden the photo-curing resin; and

\_\_\_\_ filling the photo-curing resin into the cells to be opened as the plugging material ~~for~~that forms a mask.

8. (Amended) The method of producing a ceramic body according to claim 7, wherein the plugging material ~~for~~that forms a mask filling step further ~~comprising~~comprises the steps of:

\_\_\_\_ immersing the other end face of the ceramic honeycomb formed body into a photo-curing resin before hardening;

\_\_\_\_ emanating a light to the photo-curing resin from the one end face through a mask, in which a light is transmitted only to the cells to be opened, so as to harden the photo-curing resin; and

\_\_\_\_ filling the photo-curing resin into the cells to be opened as the plugging material ~~for~~that forms a mask.